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THESIS

FRAMEWORK FOR DEVELOPMENT OF EDUCATIONAL MULTIMEDIA

by

Hugh P. Brien

March, 1995

Advisor: William J. Haga

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Multimedia based software released up to now has been of poor quality. However, multimedia technology has shown a capacity to improve education and training. A framework for the construction of educational multimedia provides a path for speeding development and creating a better quality product. There is little research being done on educational multimedia from an analysis and design perspective. A framework needs to be software independent to be useful.

This thesis provides a framework to develop educational multimedia applications. Using a systematic development approach this framework provides an implementation- independent methodology for developing educational multimedia applications. Using various approaches to software development and educational design theory, this framework gives an educational multimedia developer the tools and method to produce a quality project, on time, and under budget.

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FRAMEWORK FOR DEVELOPMENT OF EDUCATIONAL MULTIMEDIA

by

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ABSTRACT

Multimedia based software released up to now has been of poor quality. However, multimedia technology has shown a capacity to improve education and training. A framework for the construction of educational multimedia provides a path for speeding development and creating a better quality product. There is little research being done on educational multimedia from an analysis and design perspective. A framework needs to be software independent to be useful.

This thesis provides a framework to develop educational multimedia applications. Using a systematic development approach this framework provides an implementation-independent methodology for developing educational multimedia applications. Using various approaches to software development and educational design theory, this framework gives an educational multimedia developer the tools and method to produce a quality project, on time, and under budget.

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I. INTRODUCTION

A. FRAMEWORK JUSTIFICATION

The goal of this thesis is build a framework for the development of educational multimedia applications. The framework is intended to be a path that a developer may follow to guide him or her during the development process. It attempts to merge instructional design and multimedia software development together to improve the quality and effectiveness of educational multimedia. The availability of educational multimedia applications is growing in the United States (Electronic Industries Survey, 1994). A study completed by DataQuest stated that the consumer market for multimedia is presently at $16 billion while demand in business is $2 billion and the market continues to grow (Jerram 1994; Electronic Industries Survey, 1994). As a result, applications developed are sub-standard and are lacking any educational value (Amirrezvani, 1993; Schank, 1994).

This new educational technology may change the way learning is conducted in the future (Schank, 1994). To aid the transition to the this new technology, a simple framework for developing educational multimedia is presented to develop quality educational multimedia applications quickly and efficiently. The benefits provided by using an organized approach for the development of multimedia computer applications are (Whitten et al, 1989; Mallon, 1994):

- Organized development.
- Reduced development time.
- Reduced cost.
- Higher quality applications.
- Better learning environment.

1. What Constitutes A Framework For Educational Multimedia Design And Analysis?

A framework is defined as "A skeletal structure to support of enclose something." This thesis provides a skeletal structure to support the development of educational

multimedia. Therefore this thesis is an unprecedented success. A framework provides a developer with a guide for creating educational multimedia. The guide should provide:

- Methods for creating a specification for an application.
- Methods for selecting the most effective way to present information; i.e.. tutorial, simulation, drill and practice, or exploration.
- Can effective leaning theory be merged with effective educational multimedia development?

2. DoD Relevance

Education and training is a required for maintaining readiness in the Department of Defense. During this period of "right sizing" in the DoD, new ways of saving money need to be explored. Using multimedia technology will decrease expenditures on education and training (Miller, 1991). Computer based education and training could be used to decrease spending in the following ways:

- Effective on the job training.
- Shorten or eliminate training specific training programs.
- Reduce the number of funded training sites.
- Provide a better quality learning environment.

This thesis provides a framework that could assist DoD in designing and specifying educational multimedia applications. Documenting design before implementation would simplify the authoring and programming of a multimedia application. Creating a specification document during the design phase will simplify updating and maintaining an application.

3. Significance Of Multimedia

The availability of powerful home computers such as the 486DX66 and Pentium™ have made multimedia a common household word. A study by Electronic Industries Association (1994) revealed the following:

- 8% or households in the United States have a multimedia PC. A multimedia PC is defined as a PC with speakers, a sound board, and a CD-ROM drive.
- Half of all adults are familiar with the term multimedia with men seeing multimedia as computers and women likely to think of it in terms of interactive television
- 33% or U.S. homes now own at least one PC with 18% of all households planning to buy a PC by the end of 1995.

A study completed by DataQuest stated that the consumer market for multimedia is presently at $16 billion while demand in business is $2 billion (Jerram, 1994). Additional data from the survey of multimedia showed, of 200 large corporations, 22 percent are using mixed media to improve internal training courses. Benefits to business from multimedia are in business training and marketing presentations. These figures reveal that multimedia is a growing field and that there is still room for additional growth (Jerram, 1994).

There are many benefits to educational multimedia (Miller, 1991). Two reasons for using technology are reducing learning time and reduced costs. Miller (1991) asserts that "interactive technologies reduce learning time requirements by an average of fifty per cent." Miller (1991) asserts that reduced learning time is a result of the following:

- self-paced instruction encourages students to take the most efficient path to content mastery.
- the combination of visual presentation with audio explanation delivers information in an easily understood format.
- personalized instruction accommodates different learning styles to maximize student learning efficiency.
- immediate interaction and feedback provides constant, highly effective reinforcement of concepts and content.

Reduced savings from using multimedia applications is in the production of an educational program. Once an educational multimedia application is constructed, educational costs decrease as more students use the application. Miller (1991) cites an example of significant cost savings: "Federal Express expects to save over $100 million by using interactive systems for employee training" (Miller, 1991).

B. PRIMARY RESEARCH QUESTION

In the development of an educational multimedia framework the following research question was derived:

- Can an effective framework be developed to guide educational multimedia development?

The initial research for this thesis revealed minimal research in this area. Much of the research is in specific areas of multimedia or education. Proponents of technology in education assert that multimedia technology is useful but neglect to provide tools to create multimedia (Schank, 1994; Miller, 1991). Having easy to use multimedia authoring software should not preclude conducting system analysis and design. The fundamental goal of this thesis is to derive a framework that enables systems analysis and design to be incorporated into the multimedia development process. This thesis will develop a specialized tool to be used in the development of educational multimedia.

C. SECONDARY RESEARCH QUESTIONS

The secondary research questions are asked to see if any software development methodologies could be incorporated into the multimedia framework developed in this thesis. These secondary research questions are:

- Can systems analysis and design be integrated into such a framework?
- Can object-oriented analysis and design be integrated into such a the framework?
- How can structured systems design be integrated into such a framework?

These secondary questions were asked to determine which methodology, if any, improves the development of educational multimedia. Systems analysis and design should have provided a starting point for developing the framework while object oriented and structured systems design should provide an aid to determining a way to create specifications for a multimedia application.

II. LITERATURE REVIEW

The work in the field of multimedia development has expanded in the past 4 years (Electronic Industries Association, 1994). The rapid expansion of multimedia has been enabled by the available of low cost high speed microprocessors such as the 486 and Pentium™. These processors have put high powered multimedia workstations into approximately 8% of America's households (Electronic Industries Association, 1994).

Many of the resources found on the subject are as recent as six months to one year from the date of this thesis (March, 1995). Because research in multimedia is unfolding rapidly, a goal of this thesis was to provide timely information that would not be obsolete six months after completion.

The Internet provided current information on education and multimedia. Over a six month period, using the World Wide Web and the search tools available therein such as Lycos Search Engine and Webcrawler, a wealth of information on education and multimedia were found. Additional information was also found through America On-line® and Computer Select®.

A. DEFINITION OF MULTIMEDIA

1. What Are Multimedia?

Multimedia is the simultaneous use of different media to communicate effectively ideas or knowledge using a computer (Hodges and Sasnett, 1993; Schneiderman, 1989; Blattner et al, 1991). These media include text, graphics, audio, video, still images, and animation put together in a systematic way educate or inform an observer or user.

Other individuals prefer to use other terms such as hypermedia or multi-modal (Hardman et al, 1994; Blattner et al, 1992). Research revealed many attempts to reduce multimedia to their highest level of abstraction with a single word (Hodges and Sasnett, 1993; Schneiderman, 1989; Blattner et al, 1991). It seems as if lot time and effort have

gone into finding the right word that will encompass the entire study of multimedia technology (Hodges and Sasnett, 1993; Schneiderman,1989; Blattner et al,1991).

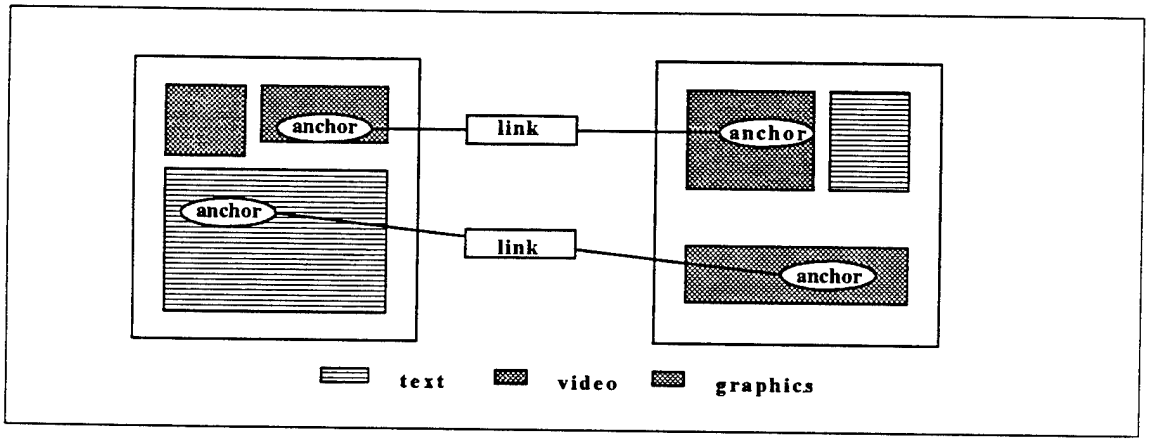

Figure 2-1

Hypertext is a database that has active cross-references and allows a reader to jump to other parts of the database as in a non-linear fashion (Shneiderman and Keasly, 1989). The structure of hypertext is that of electronic textual information linked by using a set of links and nodes. Each link has an anchor node and a destination node. Using a mouse, a word or collection of words on a computer screen may be pointed to and selected and as a result a new location in a document is displayed or a new document is displayed (Nielsen, 1990; McGinn, 1991). Examples of hypertext are Microsoft Windows® Help programs and World Wide Web browsers such as Mosaic and Netscape. An example of hypertext structure is shown in Figure 2-1.

Hypermedia is: graphics, animation, video and audio put in a hypertext format. The difference in the structure lies in the fundamental difference between static textual media and dynamic time dependent information such as video, audio and animation. For the purposes of this paper hypermedia and multimedia are synonymous. The underlying structures of hypermedia applications and multimedia applications will be discussed in more detail later in this chapter.

B. LEARNING THEORY

People learn in different ways. The key to applying learning theory to computer applications is determining the best way to present information to a user so he or she can effectively and efficiently learn the what is presented. Along with presentation, media selection is an essential aspect of the multimedia application development.

1. Cognitive Learning Methods

There are many diffe:ent approaches to imparting knowledge an individual. Using computer technology to assist in individual instruction is not a new idea. However, the effective use of technology in aiding education has not been fully exploited (McGinn, 1991). McGinn (1991) presents five methods of learning and evaluates whether the methods are effectively coupled with computer technology:

a. Sponge Method

A user is presented with information in the forms of text media. The user is then asked to answer questions based on what is presented. The user is essentially passive and is not required to interact with the application. This method has been essentially ineffective in using technology to improve learning.

b. Cognitive Apprenticeship Method

A user is presented with media that shows how to perform a specific task. By repetitively viewing the information the user can learn how to perform the task but may not receive basic knowledge or background that could be important to the task In addition the user is not required to perform the task. Again, like the sponge method, the interactive benefit of a computer is lost with this method.

c. Artist And Exploration Method

A user is presented with an "information domain" by the computer. Given a set of onscreen navigation tools a user may browse the information domain. The problem with this method is the lack of structure and guidance provided to a user. The possibility of getting lost in the domain may occur. This type of method is used in interactive encyclopedias.

d. Research Method

The research method requires the student to conduct research in a particular subject area and then report on the subject. This type of method is little more than a book report. In addition it is just an extension of the research method. When searching a large information space, a user may get lost or distracted. As a result the learning experience is not efficient.

e. Argument Method

This argument method resembles is the same as the research method with the exception that the student is required to do research and then take a position and defend that position. The same problems apply for the argument method as they do for the research method.

2. Schank's Teaching Architectures

Schank presents learning architectures that are used with computer technology. Of the following architectures, Schank recommends simulation as the most effective.

a. Simulation - Learning By Doing

Simulation allows students to experience events that would otherwise be impossible or impractical in a normal learning environment. The most apparent use of

simulation is in the field of aviation. Flight simulators allow pilots to test their abilities in extreme circumstances without the danger of death.

b. Case Based Teaching

This architecture tells students exactly what they need to know when they need to know it. This architecture is combined with simulation. The simulation provides the task while the cased based architecture provides instruction.

c. Learning By Exploring

Two concepts in this type of system are: students must be free to follow their own paths and multiple experts should be available to answer their questions. This method allows a student to browse through an information domain but have some have their questions answered by an expert.

d. Goal Directed Learning

Goal directed learning starts with a particular educational goal and provides an environment that is allows them allows them to continue at their own pace and giving them opportunity to adapt.

C. TYPES OF INSTRUCTIONAL DESIGN

1. Instructional Design Overview

The primary source of instructional design came from Tatomer (1994). Tatomer (1994) provided a comprehensive summary of instructional design. Included in his review of instructional design are the following key elements

- Four assumptions concerning instructional design.
- Systematic design.
- Performance objectives.
- Media selection.
- Instructional Systems Development.

a. Four Assumptions

The principles presented outline what is needed to build an effective instructional system. Four assumptions are made concerning instructional design.

- Instructional design must be aimed at aiding the learning of the individual.
- Instruction should be divided into for long-term and short term phases. The short-term phase is related to daily lesson plans while long term goals are related to an entire course curricula.
- Systematically designed instruction can greatly affect individual human development.
- Instructional design should be conducted using a systematic approach.

b. Systematic Design

The systematic design breaks the instructional design process into three levels: system, course, lesson and evaluation. The first three levels are a guide to developing an entire course of instruction. The last level, evaluation, reviews the course of instruction and provides guidance for revision and testing. A systematic design process is shown in Figure 2-2.

1. **Systems Level**
    - *a. Analysis of needs and goals*
    - *b. Analysis of resources, constraints, and alternate delivery systems*
    - *c. Determination of scope and sequence of curriculum and courses*
2. **Course Level**
    - *a. Determining course structure and sequence*
    - *b. Analysis of course objectives*
3. **Lesson Level**
    - *a. Definition of performance objectives*
    - *b. Preparing lesson plans*
    - *c. Developing, selecting, materials and media*
    - *d. Assessing student performance*
4. **Evaluation System Level**
    - *a. Teacher preparation*
    - *b. Formative evaluation*
    - *c. Field Testing*
    - *d. Installation and Diffusion*

Source: Gagne, R.M. and L.J. Briggs, *"Principles of Instructional Design"*, 2nd ed., Holt Rinehart, and Winston, Inc., 1970.

Figure 2-2

c. Performance Objectives

Performance objectives are the foundation upon which an educational system is constructed. The performance or learning objectives should specify be built around outcomes and not procedures or processes. An outcome is something a student is expected to accomplish as opposed to a procedure or process which tell a student how to do a task (Tatomer, 1994). The significance of learning objectives are described by Tatomer (1994):

- Objectives provide a foundation for establishing what a system will accomplish and how a system will accomplish it.
- By stating objectives, some form of evaluation can be performed to see if objectives have been accomplished.
- Learning objectives give a user an idea of what is to be accomplished.

2. Instructional System Development

Instructional Systems Development (ISD) was first developed by the military during the 1950's. Since that time, it has been used by both the military and industry to reduce the cost of training personnel. The ISD process is shown in Figure 2-3:

1. Analysis: in this phase the developer gathers and analyzes information to determine:

a. whether training is the appropriate organizational response of a problem.
b. what goals and objectives should the training accomplish.
c. profiles of individuals needing the training.
d. what resources are available.

2. Design: this phase prepares the developer for selecting and writing program materials. During this phase the developer will:

a. write lesson/program objectives.
b. develop test items.
c. determine design structure and sequence.
d. decide what documentation will be needed for the training program.
e. plan program evaluation.

3. Development: in this phase, a developer prepares materials for:

a. training participants
b. instructor use
c. training documentation
d. training participants evaluation
e. program evaluation

4. Implementation: in this phase the program is actually carried out. Typically, this means that classes are held, self paced courses are begun, or on-the-job training starts.

Evaluation/Control: this phase involves internal and external evaluation of the training program itself.

Tatomer, William J., *Development of a Squadron Premishap Training Program,* Master's Thesis, Naval Postgraduate School, Monterey, CA, 1993)

Figure 2-3

Ciavarelli (1994) describes the ISD process: "This method outlines a set of procedures of developing instructional programs based on job or task performance requirements and selection of the most appropriate instructional delivery strategies for specific learning objectives." The ISD method of developing learning instruction is summarized by the following four principles from Ciavarelli (1994):

- Content is based on analysis of job/task requirements.
- Performance oriented instructional objectives are explicitly defined for each task to be learned.
- Instructional quality is evaluated during all phases of development and after implementation.
- Choice of instructional delivery method, media selection, and evaluation criteria are chosen on some rational basis

3. Component Display Theory

The component display theory (CDT) attempts to explicitly define and classify learning outcomes. In addition, CDT precisely determine the forms of instructional presentations required to improve instructional quality and effectiveness. The CDT attempts to break all forms of instruction into three components:

- Objectives - what a student is supposed to learn.
- Activity - tasks requiring student participation to meet objectives.
- Tests - used to ascertain whether objectives were learned by the student. (Ciavarelli, 1994)

Learning objectives are the foundations on which an educational lesson or system is built. A well stated learning objective is one which has:

- Behavior -- a single, student-oriented behavior expressed by an action verb
- Conditions -- a precisely stated description of performance conditions
- Criterion -- a specification of standards of performance (Ciavarelli, 1994)

Component display theory recommends the best path for fulfilling a learning objective. Learning objectives are classified into a two dimensional matrix with the following axes: required task performance and subject matter content. The CDT is based on "each learning objective has its own "prescription" of how best to present and test instruction" (Ciavarelli, 1994). The CDT gives direction for a developer to follow in attempting to develop a route to fulfilling the learning objectives.

To use the matrix, first determine the task that a student must perform: find, use, or remember. Then determine the type of information the student must learn.

Task Content				
Task Level	Fact	Category	Procedure	Principle
Find	Recall or recognize names, parts, dates, etc.	Remember the characteristics of each category and the guidelines for classification	Remember the steps of a procedure	Remember the cause and effect relationships or the statement of a principle.
Use		Given a category characteristics and guidelines, categorize objects, events, ideas according to characteristic	Given steps of the procedure, apply the procedure in a single situation or on a single piece of equipment	Given a statement of the a principle, interpret or predict why or how things will happen.
Remember		Classify or categorize objects, ideas, events, according to their characteristics with no memory aid	Apply the steps of the procedure in a single situation or on a single piece of equipment with no memory aid	Use the principle to interpret or predict why or how things happened or will happen with no memory aid

Table 2-1

"During the design of new instructional materials, each learning objective is classified in accordance with the following definitions which serve to place a particular objective in a particular cell" (Ciavarelli, 1994). The components of task performance and content shown above are described below. The item defined under task performance are:

- Remember -- requires the learner to recall or recognize some item or information from memory
- Use -- requires the learner to apply some procedure, principle or demonstrate some skill
- Find -- requires the learner to create something new

The items described under content are:

- Facts -- arbitrary pieces of information, such as names, symbols, dates, or events.
- Characteristics -- groups of things that are related because they share the same or similar attributes.
- Principles -- relationships between concept classes, or "scientific" lawful relationships.
- Procedures -- a set of sequential steps designed to accomplish some specific task in a required order (Ciavarelli, 1994).

A lesson should follow some guidelines when presenting a lesson. Under CDT the basic guideline is RULE, EXAMPLE, AND PRACTICE. A lesson prepared using CDT should look something like this: Rules are stated concerning the topic, such as definitions, heuristics, principles or any other factual data. Following rules, example are shown to the student. After examples, the student is required to perform a task or complete a learning exercise. Finally, the student may be tested on the material.

D. TYPES OF MULTIMEDIA APPLICATIONS

The research in this section revealed different types of multimedia applications. They are education and training, presentations, and entertainment.

1. Education And Training

Education and training applications are used in industry and educational fields to educate students and employees. The reason for using educational multimedia in industry and education is to make training more effective and more cost efficient (Jerram, 1994). Education and training applications are divided into four types. They are: tutorial, simulation, drill and practice, and exploration (Schank, 1994; Jerram, 1994).

a. Tutorials

Tutorials are usually passive type systems that provide a user with information. Users normally use a pointing device to push a button or choose from a list

to continue to another screen or a new subject area. The advantage of a tutorial system is that it is simple to construct. If a developer has a quality multimedia authoring system, a small project can be put together is an little as a day (Ciavarelli, 1994).

b. Simulations

The simulation provides a "virtual" environment where a user must simulate performing a task using a computer. The best example of a simulation system is a flight simulator (Schank, 1994). A student flying the simulator can make mistakes that would be very costly if made in an actual airplane. Simulators are excellent tools for instructing but are normally very complex and expensive systems (Schank, 1994; Ciavarelli, 1994).

c. Drill And Practice

Drill and practice applications are tools to assist in memorization. They provide a user multiple questions and answers. Schank flatly rejects drill and practice as an effective method for computer based multimedia educational applications (Schank, 1994)

d. Exploration

The exploration application is a large "information space" through which a user navigates using different forms of interaction: pushing buttons, pointing to hypertext, or pointing to graphics. In addition, exploration applications may also provide virtual guides to aid a user navigate though the information space. The *Americana Series: A CD-ROM Sampler of American History* provides such guides to assist a user navigate through American history (Blattner, 1994). The exploration application is effective, however, if a user is not provided direction, he or she may get distracted or lost in the information space.

2. Presentations

Presentations are use primarily in business and industry for marketing and sales. Presentation are used extensively in industry to give information about a product or service to a potential customer. A survey revealed of 200 companies using multimedia in their business, 66% of used multimedia presentations (Jerram, 1994).

3. Entertainment

Entertainment multimedia applications have the largest market share of the multimedia industry. A survey conducted in 1994 revealed that the entertainment multimedia market is a $16 billion industry. Entertainment multimedia applications cover a wide spectrum of subjects including adventure games, children's educational games and multimedia encyclopedias (Jerram, 1994). Some new types of applications are multimedia extensions of popular software. TurboTax® on CD-ROM now comes with a tax assistant/advisor who can give a user advice tax preparation. In addition, Compuserve now publishes a monthly CD-ROM based magazine.

E. METHODOLOGIES OF MULTIMEDIA DEVELOPMENT

1. Mallon's Home Page

Mallon's Home Page on the World Wide Web (WWW) provided a continuing wealth of knowledge that developed over the period of ten months. This resource is unique because it was a research resource presented in a multimedia format, specifically a hypermedia format. Mallon (1994) provided an introductory outline to multimedia development that is continually being updated. It has now developed into an entire multimedia development process. The framework presented in this thesis was developed concurrently with Mallon's development process.

Mallon provided some essential ideas to the multimedia development process. The most valuable tool recommended by Mallon is storyboarding. Storyboards are tools used to visually describe a screen layout before implementation. Storyboards are used

extensively in the film industry. The following are the primary the initial issues presented by Mallon in his multimedia development process:

a. Storyboarding

A storyboard is an expression of everything that will be contained in the program--what menu screens will look like, what pictures will be seen when and for how long, what audio and text will accompany images, either synchronously or hyperlinked" (Mallon, 1994).

"The storyboard expresses, in one way or another, everything that can be seen or heard or experienced by the end-user of the multimedia program. It's more that a test of concept model, and just short of the final product specification document" (Mallon, 1994). Mallon gives advantages of storyboarding:

- It helps catalyze feelings about the feasibility of the program ideas. If the storboard looks wrong the program will too.
- Omissions my be spotted as a result of producing the storyboard.
- There is a document which everyone can point to as a common point of reference, enabling the design team and client to say 'Yes that is what I meant, or 'No, we've a problem here.
- The storyboard helps focus on the total content of the program, both from the point of view of the overall size of the program and in discussing user interaction times.
- Problems may be spotted from the storyboard which may have proven more costly to correct at a later stage.
- A detailed storyboard can save time in writing project documentation, for example, in the product specification document.
- Advanced planning can result in templates of the content writer to work with. This speeds up the content writing process and makes the production of the storyboard itself so much faster.

b. Multimedia Interface Design

Interface design is an essential element of a successful multimedia application. Mallon provide a list of over 50 user interface design recommendations. The

recommendations are divided into specific areas: screen layout, use of color, and use of sound. Mallon's (1994) first recommendation for screen layout is "screen layouts should strike a structured balance between information, interest and accessibility." Screen layout needs to capture and hold the attention of a user but not be busy. The screen should not be cluttered with too much information. Mallon also adds the following:

- Do not use more than three fonts per screen Don't assume everyone understands your icon.
- Navigating a program should be intuitive and easy to follow.
- Offer users a way of backing out of significant or time-consuming pathways such as quitting or printing.

Mallon (1994) says that the improper use of color can be detrimental to an a multimedia application. He cautions using "cool" and "hot" colors together such as "bright orange next to bright blue. Such colors come into focus for the eye at different distances and the viewer may make head movements back and forth or rapidly blink in an attempt to refocus on different screen areas. This phenomenon can cause the viewer to feel uncomfortable and experience dizziness and nausea." In addition, Mallon recommends that too many colors make reading the screen difficult. To reduce flicker at screen edges use muted or mid- to dark-gray colors there. Finally, Mallon addresses color blindness. "Color blindness results in the confusion of reddish hues with greenish hues and yellowish reds with yellowish greens. Opposing red with cyan and yellow with purple reduces misinterpretation" (Mallon, 1994).

Sound is another interface design issue. Mallon asserts that "sound quality issues deserve as much attention as the quality of the graphics" (Mallon, 1994). In addition, Mallon proposes several more worthwhile suggestions when working with sound.

- Recorded human voice is preferred to computer-synthetic voice
- Allow sound levels to be altered according to ambient conditions.
- Repetitive sounds from interactive systems can be extremely annoying

2. Multimedia Computing: A Theoretical Framework

Hodges and Sasnett (1993) presented a theoretical "framework for discussing issues of visual design." Their design framework relies on principles used in studying film. Hodges and Sassnett's framework was an outstanding guide for building a well designed multimedia application that is intuitive and aesthetically pleasing. The framework is divided in two primary subjects: mise-en-scéne and montage. mise-en-scene

"Mise-en-scéne treats the construction of individual scenes--what objects are included, how they are framed and composed" (Hodges and Sasnett, 1993). Mise-en-scène is concerned with what is displayed and how it is displayed on a storyboard. It motivates a developer to create screens that have visual and information balance. Information balance is a concept where important information is viewed first as a screen appears. The screen should be created so that it leads the eye the most important information being displayed. In addition, important images or text should not compete for the user's attention. If the goal of the screen is to show a piece of video, other media objects should be kept to a minimum (Hodges and Sasnett, 1993).

- construction of individual scenes.
- objects included in individual scenes.
- framing.
- composition.

3. Montage

Montage is concerned with the presentation, ordering and transition of multiple storyboards. Consistency is an additional aspect of montage. The underlying metaphor and screen presentation should be consistent throughout. An example of consistency is the similar look and feel of applications that run in the Microsoft Windows® environment.

- combination of scenes.
- which scenes are chosen.
- how scenes are sequenced.
- transition from one scene to the next.

4. The Multimedia Authoring Process

In a paper presenting a metaphor based authoring system, Vaananen (1993) presents a basic multimedia authoring process. This was one of the few development processes found during the literature review. The process was general and had little detail. Vaananen (1993) presented the process in Figure 2-4

1. **Preparation (collection and editing) off multimedia data**
2. **Design information structures**
    a. ***Design of media dependent representations of information items***
    b. ***Design of media combinations***
    c. ***Design of information structures***
3. **Design user interface**
    a. ***Design of metaphors in the user interface***
    b. ***Design of interaction methods***
4. **Realization (programming) of the system**
    a. ***Implementation of methods for integrating information units within the system***
    b. ***Implementation of methods for structuring the information***
    c. ***Implementation of metaphors***
    d. ***Implementation of interaction methods***
5. **Integration of multimedia information units within the system and the creation of connections (links or groupings) between them.**

Source: "ShareME: A Metaphor-based Authoring Tool for Multimedia Environments", *Proceedings on Human Computer Interaction,* Vienna Austria 1993; Springer-Verlag 1993.

Figure 2-4

F. MULTIMEDIA MODELS

1. The Dexter Hypertext Model

The Dexter Hypertext model was originally developed to model simple hypertext systems. It is composed of three layers: *runtime, storage, and within component* (Halasz and Schwartz, 1994). The storage layer is essentially a database for identifying, storing

and linking elements of media data. The storage layer is shown in Figure 2-5. The storage layer defines all media data as *atomic components.* A component is either a single media item, such a graphic, or a *composite component*, which is a set or collection of media items.

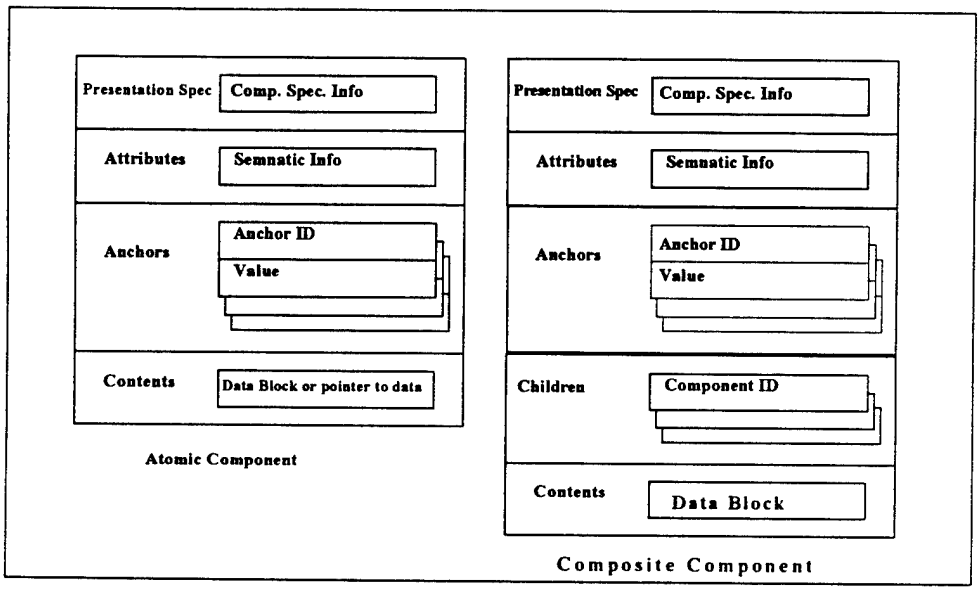

Figure 2-5

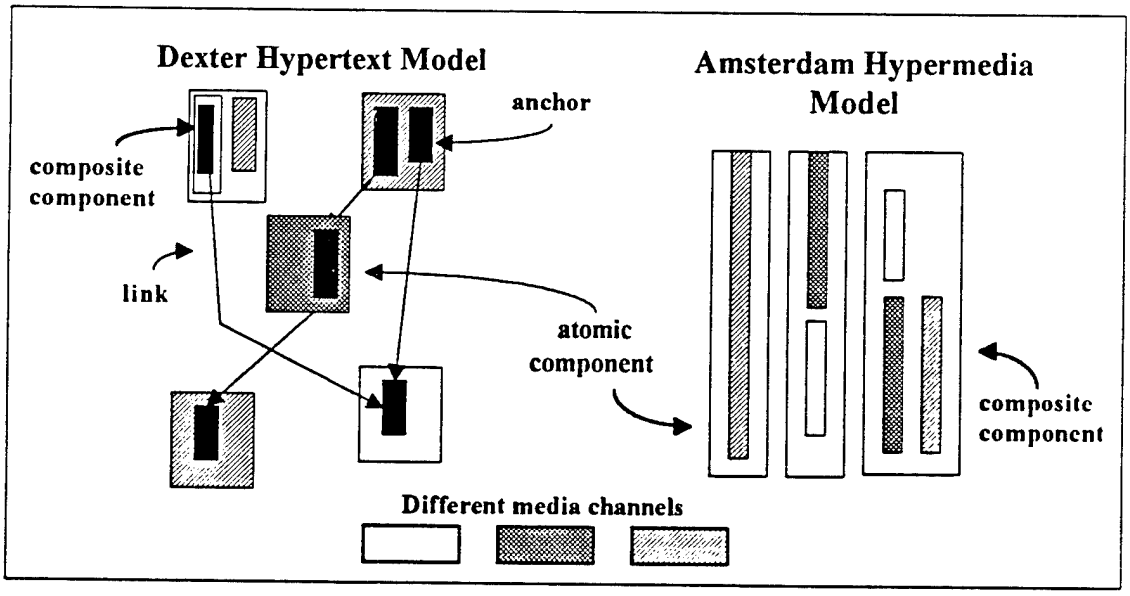

Figure 2-6

In addition, to storage data the model also defines anchors and links. Using links and anchors, components in hypertext document systems can be connected. Anchors and links are the elements that connect components together to form the "network structure that is the essence of hypertext" (Halasz and Schwarz, 1994) An anchor is a single piece of media that can be pointed to with a mouse and "clicked". The "click" follows the "link" to display a new component to which the link points. Examples of links and anchors are shown in Figure 2-6.

"The fundamental concept in the runtime layer is the instantiation of a component. The instantiation is a presentation of the component to a users" (Halasz and Schwartz, 1994) The presentation of a text component is separate from its content. The presentation specification in the case of text, would be a description of font, color, and size of the text while the content would be the words in the text. The channels are shown in Figure 2-6.

The within component layer is "specifically concerned with the contents and structure within the components of the hypertext network" (Halasz and Schwarz, 1994). The contents would be the actually media items that are pointed to by the component definitions. The structure of how the data is stored is also not a concern of the Dexter model because a hypertext application could be on a lone workstation or be part of a local area or wide area network.

The main problem with the Dexter hypertext model is that it only allows links between two components. While it provides a well defined data structure it does not account for time based media such as sound, video and animation, that is prevalent in so many multimedia applications. Time based media would be video, sound, and animation. In addition it does not account for synchronization between two time based media objects. For example starting a sound track synchronized with an animation sequence (Hardman et al, 1993).

2. The Amsterdam Hypermedia Model

The Amsterdam Hypermedia model (AHM) is the most comprehensive model for multimedia and hypermedia. The Amsterdam Hypermedia Model adds time and context to the Dexter hypertext model. "The AHM was developed to provide a comprehensive basis for combined multimedia and hypermedia research" and a framework for describing the basic constructs and actions that are common to a wide range of hypermedia systems (Hardman et al, 1994).

Figure 2-7 shows the data model for the AHM model. There are two main changes when advancing from the Dexter model to AHM. The differences are that AHM accounts for time and presentation while still maintaining the all the features of the Dexter model. Time is accounted for in the AHM model using component composition and synchronization arcs while presentation is accounted for channels.

The composite components allow different components to be grouped together in a hierarchy structure meaning a composite component can contain many other composite components or atomic component. Components stored within anther component are children components of the parent component in which they are stored.

> "When grouping components into a presentation, timing constraints among the children of the composite components need to be specified. These can be specified with respect to the parent component or with respect to other sibling components" (Hardman et al, 1994).

> "In the Amsterdam model, a composite component specifies the children comprising the composite. These may be atomic components or composite components. Composite components can be of two types. parallel or choice, where a parallel composite component means that all its children are played and choice composite component specifies that at most one of its children is played" (Hardman et al, 1994).

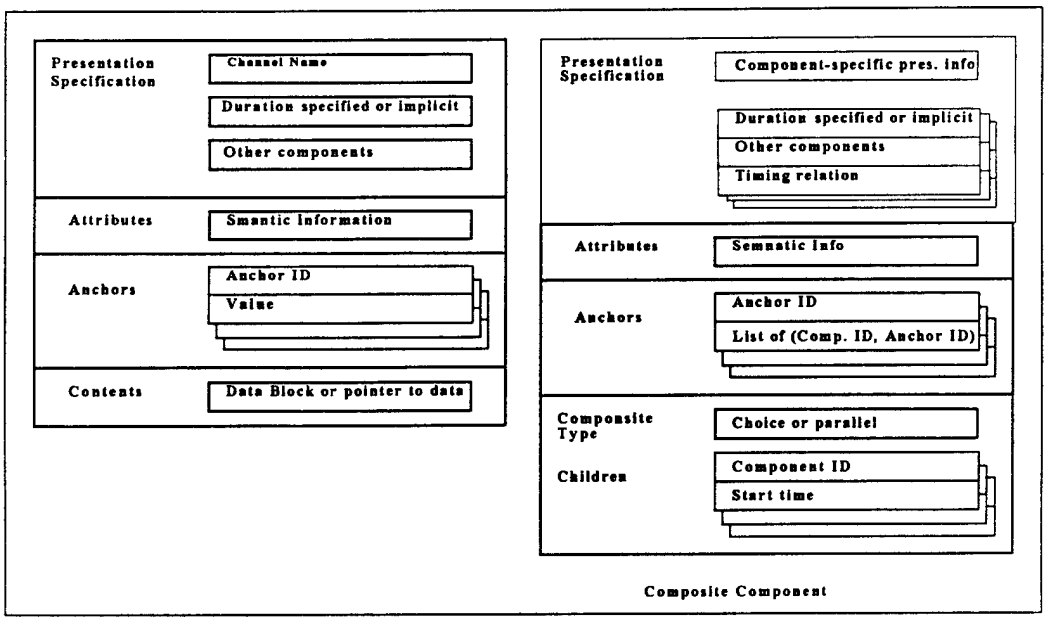

Figure 2-7

The formal definition of a channel by Hardman et al. (1994) is an "abstract output device for playing multimedia items. "A channel is serves two purposes in the AHM. It contains the presentation specification of a component or a composite component. "The channel defines the default presentation characteristics for the medium using the channel" (Hardman et al, 1994). The advantage of specifying a channel is that it allows the developer to design a reusable layout that is not dependent on content rather it is dependent on media type.

III. FRAMEWORK

Multimedia provide a powerful tool that is a proven asset to education (Miller, 1991). Needed for effective multimedia development is a framework to guide planning, design and implementation (Miller, 1991). A framework should:

- be easy to use and understand.
- reduce cost of development.
- shorten development time.
- improve performance of final multimedia product.
- implementation independent.

Implementation independence means that the framework transcends the authoring software tools used to build a system. A framework is divided into three phases:

- analysis.
- design.
- parallel issues.

The analysis phase addresses various stages of planning an educational multimedia application. The design phase provides a specification for application implementation while parallel issues provides information on hardware, operating systems, authoring software, and media editing software to aid in selecting the best tool for each individual project.

The framework for multimedia development developed here is attempts to bring together concepts, models and ideas from the diverse domains of educational development, software development and multimedia development. This framework has been derived from these development methodologies and models: object oriented analysis, structured systems analysis, instructional design principles, computer based education analysis, multimedia document models, and multimedia information management models (Whitten et al, 1989; Rubin and Goldberg, 1992; Alessi, 1991; Hardman et al, 1993).

A. ANALYSIS PHASE

The analysis phase is the planning and organization phase of this multimedia framework. The following steps central to the analysis phase:

- define learning objectives.
- identify end users.
- define an application metaphor.
- collect multimedia resources.

The analysis phase starts the merger of multimedia resources with educational learning objectives. The analysis enables developers to learn about the subject material that would be included in an educational multimedia application.

The first three steps in the framework are derived from the Instructional Systems Development (ISD) model. The ISD model was used by both the military and private industry during the 1950's and 1960's for the development of training programs (Tatomer,1994). ISD has proven to be an effective and cost saving approach to developing education and training programs. It is composed of five phases: analysis, design, development, implementation, and evaluation. (Tatomer, 1994).

1. Define The Goal Of The Application

The first step in the analysis phase is defining the what an educational multimedia application is to accomplish. All efforts during multimedia development should contribute to meeting the goal of an application. For an educational multimedia project the successful mastery of the learning objectives is the goal. Failing to master the learning objectives will result in one more useless multimedia CD ROM available at any software retailer.

2. Identify End Users

Identifying end users is as important as defining learning objectives. The system is for an end user's benefit. Whitten et al. (1989) emphasize this point, "End-user

involvement is absolutely necessary for successful systems development." End user attributes that need to be addressed in this step are taken from Alessi (1993).

- age.
- educational level.
- reading proficiency.
- general motivation
- experience in subject.
- interest in the subject.
- computer familiarity.

End user analysis gives direction in selecting the appropriate media, user interface, and application metaphor. Finally, it is critical that end users be involved in the development process.

3. Define Detailed Objectives

Learning objectives are the foundation of the educational multimedia application. Well defined learning objectives make applications effective or useless. Fancy visual and sound effects make for an entertaining application but may accomplish little and quite possibly become annoying. An application without an underlying structure of well defined learning objectives will entertain end users but will not educate them. When users are finished using an application they should have, at a minimum, a working knowledge of the learning objectives.

Three reasons for defining detailed learning objectives are provided by Tatomer (1994):

- Objectives provide a foundation for establishing what a system will accomplish and how a system will accomplish it.
- By stating objectives, some form of evaluation can be performed to see if objectives have been accomplished.
- Learning objectives give a user an idea of what is to be accomplished.

The learning objectives provide guidance for how the information will be presented in the application. are defined, presentation type can now be determined.

4. Define Application Type

There are two basic application types presently used in educational multimedia applications: active learning and passive learning. An example of active learning would be a simulation program that would first show a user how a task is accomplished and then ask a student to perform the task. An example of passive learning is a page turning application where a user reads text and watches video about a task (Schank, 1994).

Schank (1994) recommends application types that involve some active learning. He provides an illustration: "Multimedia programs fail because they merely add video and graphics to page turning programs. Consider remote control television which is a type of multimedia. By pushing buttons for new channels the user can access many streams of continuous information." What the user in the television example is doing is what many multimedia applications provide--pushing screen buttons to turn pages or play audio tracks.

5. Develop The Metaphor

Developing the metaphor is one of the most difficult steps in the analysis phase. It is also an important step because it will define how a user will interact with an application. Blattner (1994) defines a user interface metaphor as a "mental model or conceptual understanding of how the system works." Vaanenen (1993) defines it as "an analogy modeled upon something that is well known to its users." An example of a metaphor is the accounting program Quicken™, which uses a checkbook register metaphor to simplify user interaction with the system. Balasubramanian (1994) recommends that the metaphor should not "be too restrictive." It should not limit the developer in the design phase.

A metaphor definition needs to be determined early in the analysis phase because it will affect the total "look and feel" of the application. It also needs to follow identifying end users because an end user needs have to be known before a metaphor is selected. A metaphor should be built for the end users of an application. Vaananen (1993) cautions when picking a metaphor, "Metaphors must be chosen very carefully in order to avoid users forming incorrect mental models." To use the Quicken™ example again, if an end user had never used a checkbook before, the user interface would not be as intuitive compared to a user who had regularly used a checkbook.

6. Information Resources Search And Identification

The information search step is the most difficult and time consuming. The purpose is to find appropriate media that best convey the learning objectives. A comprehensive search of information resources based on learning objectives is required to see if enough media are available to create an educational multimedia application. This search involves primarily media objects that will be used in an application. Examples of media components are text, video, sound, graphics and animation. In addition to media, a search should include domain experts and any other reference material (Tatomer, 1994; Balasubramanian, 1994).

All types of media are required. Sources of information would be a library , the Internet, commercial services such as CompuServe® or America On-line®, and domain experts. The Internet and on-line services can be a useful information resource because of the wide variety of media available such as text, graphics, video, animation and audio. At this juncture, however, a question needs to be answered, "Will existing media be available to complete a project?" If not, a critical decision needs to made that may affect time and cost constraints (Whitten et al, 1989). The decision is whether new media such as video and animation can be produced from scratch. These are time consuming tasks that will increase the cost and time originally allocated to a project.

7. Resource And Quality Objectives

Project resources are the number of people used during development, the time of the project from start to finish, any capital investment required to complete the project, and the total number of dollars allocated to the project. If any capital investments in hardware or software are to be made, a capital return on investment should be computed before taking on a multimedia project (Rubin and Goldberg, 1992).

Quality, cost and time objectives are three primary issues, aside from the actual content of an application, that need to be addressed. A project team should have reasonable quality, cost and time objectives defined before the design phase begins. Examples of quality objectives are performance and reliability. In addition, objectives should be revisited and updated during application design, and implementation. By revisiting and updating, decisions concerning adjustments may be made such as:

- allocating a greater or fewer number of developers.
- adjusting completion time.
- additional debugging and testing .
- searching for more media.
- creating new media from scratch.

8. Media Collection, Description And Storage

Media collection and storage are the initial building blocks of an educational multimedia application. Media that pertain to the subject matter need to be acquired, defined and stored. Media possibilities should have been identified during the information resource search conducted in Step 6. For an educational application, emphasis should be placed on finding media that will integrate well with a specific application type. Simply collecting text and graphics would be better suited to a passive learning application discussed in Step 4. On the contrary, video, animation and sound would be better suited to an active application.

Issues to consider other than the type of media are the size of the media in kilobytes and the storage medium. Media such as video, sound and graphics produce large files and adequate disk space is needed to store the information. The media components gathered must be cataloged by name, size, media type and semantic information. The semantic information would be the description of the content being conveyed by the media component (Grosky,1994).

The most important issue, however, in media collection is avoiding copyright infringement. "Every time you use a copyrighted work owned by a third party, you must determine whether it is necessary to obtain a license from the owner. For most uses, a license should be obtained." Failure to do so can result in litigation (Radcliffe and Brinson, 1994). The following recommendations are made by Radcliffe and Brinson (1994):

- Copying a small amount of a copyrighted work is an infringement if what is copied is a qualitatively substantial portion of the copied work.
- Purchasing a copy of a work does not give you permission to exercise the exclusive rights of copyright.
- Lack of intent to infringe is not a defense of infringement, nor is ignorance of the copyright law.
- You need a license to copy even if you are the only one who will ever use your multimedia work.
- If you are creating a multimedia work for an educational or public service group, you should get a license.
- Even if it's true that no one will ever pay to see your work, you need a license to copy if you use a third party's copyrighted work.
- The fact that a work does not have a copyright notice does not mean that the work is not protected by copyright.
- If you give credit to a work's author, you are not a plagiarist, however, attribution is not a defense of copyright infringement.
- Do not assume that past use was licensed use.
- Foreign authors who live in countries that belong to the Berne Convention or the Universal Copyright Convention automatically obtain copyright protection in signatory countries to the conventions.

By following these recommendations, the problems associated with copyright infringement can be avoided.

9. Media Editing

Media editing breaks the raw media and information into manageable pieces that will attempt to convey the learning objectives to the user. This step is time consuming and requires an understanding of the learning objectives. For media editing, the time that it takes to accomplish this task corresponds directly to the computer and the software tools the developer is using to edit the material. Media editing involves refining the content of the media to draw out the desired information to meet specific learning objectives.

B. DESIGN PHASE

Hodges and Sasnett (1992) describe quality multimedia as "effective communication." The design phase provides the tools to create an educational multimedia tool that will effectively communicate the learning objectives defined in the analysis phase. This phase merges the educational learning objectives with different media types under a specific application to generate a quality educational multimedia system.

The design process begins by breaking the application down into manageable pieces and then creating storyboards based on the media collected during the analysis phase. Storyboards will be covered later in this section. Media components, navigation components, channels and composite components are defined from storyboards. These components will be explained later in the paper. A channel is an output style used to define default presentation information similar to paragraph style in a word processor. Finally, the functions of the navigation components will be defined . (Hardman et al, 1994)

The building blocks of the design phase are the media components. To simplify the design process, the entire application is broken down into pieces or *components*. Everything that is presented in a multimedia application is broken down into components that communicate a learning objective. Media is specified by itself or grouped into a

composite component. A composite component is just a collection of media components. These components are: media, navigation components and composite components. The specification that results from the design phase consists of storyboards that illustrate screen changes within and between scenes. Each storyboard will also contain a description of its respective media components, navigation components and underlying functionality. Media presentation information such as font type and size or graphic size and screen location will be defined within channels. The following steps make up the design phase.

1. Divide Application Into Manageable Pieces

In any big project, a developer should divide an application into logical manageable pieces. An application can be divided any way a developer sees fit. A division can be arbitrary but it should be useful. Dividing applications into pieces leads to modularization which simplifies development, implementation, and future expansion. For example, a hypertext document could be divided into chapters (Rubin and Goldberg, 1993; Feeney and Day, 1991).

2. Design Storyboards

This is the heart of the design process. Storyboards are visual representations of individual screens that will be presented in a multimedia application. Storyboards contain representations of all media that will be displayed within each screen. "A storyboard is an expression of everything that will be contained in the program--what menu screens will look like, what pictures will be seen when and for how long, what audio and text will accompany images, either synchronously or hyperlinked" (Mallon, 1994). The storyboarding process lets the developer evaluate the visual concerns before trying to implement (Alessi, 1991).

Storyboards can be produced either on paper or by computer software. There are several multimedia authoring applications that support storyboarding: Hypercard,

Macromedia Director®, ToolBook® and IconAuthor®. "The major assumption in the recommendation of this approach is that the designer is fluent in the authoring/storyboarding tools. Without this fluency, it makes more sense to pursue alternative, more traditional, paper based storyboarding techniques" (Mallon, 1994)

Storyboarding coupled with the metaphor definition are the initial steps to creating a well designed user interface. Creating storyboards addresses essential user interface design issues.

Storyboarding is used extensively in film making. The creation of storyboards during design address issues of mise-en-scène and montage. Mise-en-scène deals with how the content of specific screens fit together while montage deals with how a sequence of screens flow (Hodges and Sasnett, 1992). Storyboards bring together the metaphor and define the user interface. Alessi (1991) recommends creating a flowchart prior to storyboarding. In this framework, however, the underlying functionality will not be limited by flowcharts but will be contained within the storyboard by the components defined in them.

Once the storyboards are completed, media components are specified individually or are grouped to form composite components. These components are put together for form an instance of composite component that represents a storyboard. The storyboard is now specified as a composite component.

3. Define Media Components

Each media component can be presented as text, graphics, video, animation, or sound. Media components are defined here as components that can be seen or heard which communicate information or an idea to a user. Media components are put together in some instances to form composite components. Storyboards created in the previous section are composite components.

Consideration must be taken when deciding what media to include in a storyboard. Media bias should be taken into consideration when deciding which media to use. An

example of media bias would be that some users tend to give more credibility to text rather than video (Blattner et al, 1992).

4. Define Navigation Components

Navigation components are components that are visual representations which allow a transition to display or activate either a single component or a composite component. A simple example of a navigation component is a button on the screen that turns to another virtual page. Navigation components are composed of two anchors with a link between them (Hardman et al, 1994). An anchor could be a piece of text, an icon, or a graphic with a link to another part of the same screen or another screen.

Navigation constraints are an additional issue in a multimedia application. If an application is large with many navigation components and destinations could result in a user getting lost in the information space or repeating the same information over and over. The attributes of a navigation component, at a minimum, should be: name, media components to which it is anchored, screen components in which anchor media components are located.

5. Define Channels

"A channel is an abstract output device for playing or showing media output on a screen. An example of a channel is a window on the screen or an audio output. The channel also includes the default presentation information; for example font and style for a text channel, or volume for an audio channel" (Hardman et al, 1993). Channels are similar to paragraph styles used in word processor program. A user defines paragraph styles by defining font, spacing, margins and so forth. But the content of the text is independent of the style or presentation. Similarly, defining a video channel could involve window size, window location, and whether playback is user controlled. Again this channel or style is independent of the content of the video.

6. Define Functionality

With the media components and the trigger components defined, the functionality of the screen components can be defined. The media components or composite components are intended to have their functionality encapsulated within their respective specifications. For example a graphic will display itself . A functional description could be an instance of the following: display (graphic size, location). The point is that functions should be encapsulated within an component's specification. In addition, the function that will be utilized should be defined by the developer for their own development needs.

C. PARALLEL ISSUES PHASE

The initial premise of the analysis and design phases were to make the implementation of an educational multimedia project implementation independent. Implementation independent means that implementation of the application does not depend on the use of any specific piece of hardware or software. Assuming that an application that has been designed is feasible using existing technology, hardware and software used during implementation should be picked after analysis and design are completed. The analysis and design phases helped in deciding what is to be done while the parallel issues phase will assist in deciding how a system will accomplish the goals set in the analysis.

The following information will aid a developer in deciding what hardware and software are appropriate to build an educational multimedia system.

1. Hardware

A tool for developing personal computer multimedia applications is the Apple Macintosh®. A survey conducted by Dataquest surveyed 200 multimedia developers and found that 63% prefer the Apple Macintosh®, however the majority of their revenue will come from building applications for DOS and Microsoft Windows® (Cowles/Simba, 1993).

Regardless of what is widely preferred, the issue is what hardware is being used by people in the market for educational multimedia applications. Five years ago, the distinction between Apple computers, PC-X86 based clones, and high powered RISC workstations was clear. Minimum requirement for developing and using multimedia are presently contained in the MPC1 and MPC2 standard:

Multimedia PC Standard Minimum Requirements Recommended is in ( )		
	Level 1	Level 2
RAM	2MB	4MB (8MB)
Processor	386SX16MHz	486SX25MHz (486DX66MHZ)
Floppy Disk	1.44MB 3.5"	1.44MB 3.5"
Hard Disk	30MB	160MB (500MB)
CD-ROM	150KB transfer rate 1 second access time (64K buffer)	300KB transfer rate 400 ms access time (64K buffer)
Sound	8-bit, 8 voice synthesizer MIDI playback	16-bit, 8 voice synthesizer MIDI playback
Video	640x480x16	640x480x64K
Author: Freedman, Alan. (Multimedia PC) Requirements for a multimedia PC as specified by the Multimedia PC Marketing Council, a subsidiary of the Software Publishers Association. Address: 1730 M St., N.W., Washington, DC 20036, 202/331-0494.		

In the near future, however, as processing power increases, the real issue will be what operating system is being utilized.

2. Operating Systems

Hardware used to develop multimedia use operating systems that come in three basic flavors: DOS and Microsoft Windows applications that run on X86 and Pentium™ based microprocessors. Apple Macintosh Operating System that run only on Macintosh products, and RISC-based processors that run Unix operating systems. Examples of Unix based systems are Sun Microsystems, Hewlett Packard, Silicon Graphics. There are some exceptions. There are several versions of Unix that run on the X86 such as Linux, Xenix

and SCOUnix. In addition, there are several different Microsoft Windows® emulation programs that run on Apple Macintosh®, PowerMac™, or Unix based machine, one of which is SoftWindows™.

3. Software

After selection of the operating system, there are two primary multimedia development software type: authoring software and media editing software.

a. Authoring Systems

Authoring systems come in many varieties. There are presently at least fifty commercial authoring systems available to a developer. Authoring systems give a developer the ability to complete entire systems for distribution. Different paradigms are used in multimedia authoring systems. The three types of paradigms cited by Keogel and Hienes (1993) are :

- Outline: An outline of the presentation is constructed in a text-based outlining editor. Each outline entry can be expanded into a presentation screen which incorporates graphics, text, video, sound and interaction.
- Visual Programming: A set of icons are arranged in a graph which specifies the interactions and control the path for the presentation. The functionality associated with each icon can be modified using associated menus and editors. Typically a simple text language is available for performing calculations within an associated icon. Additionally new icons can be made using links to a programming language such as C, C++, Visual Basic or Pascal.
- Scriptware: Graphics, test and other media editors are combined with an integrated and special purpose programming language. Programs define the control and interaction behavior. The script language is typically intended to have a simple, easy to use syntax.

b. Media Editing And Manipulation Systems

Media editing software is used for editing text graphics, video, animation and sound. Many authoring system come with their own proprietary media editing software.

A specific examples of this type is IconAuthor® by Aimtech Corporation. This visual programming package comes editor for text, graphic, video, sound and simple animation. These software package provide basic tools for getting the job done but don't offer the ease or flexibly that single use package provide. An example of a video editing tool that makes video extremely simple is Adobe's Premiere™. An example of an excellent graphics editor is Adobe's Picture Publisher™ and an outstanding sound editors come packaged with both the Mediavision and SoundBlaster audio board

D. IMPLEMENTATION OF FRAMEWORK

An example application was developed in conjunction with presenting the multimedia framework. Each step of the framework was covered while developing the example. Follow the framework while reading the example. The example is a lesson from a training plan developed by Tatomer (1994) to instruct United States Naval officers in the process of aircraft mishap investigation. The lesson gives instruction on constructing and analyzing aircraft mishap wreckage diagrams. An aircraft mishap diagram is a two dimensional representation of a aircraft wreckage site. It includes the locations of:

- Apparent flight path.
- Significant aircraft parts - engines, prop, rotor blades, wings.
- Location of aircrew.
- Wind direction.
- Impact point and ground scars.

From the diagram, an investigator can review an entire mishap site and try to infer facts about an aircraft mishap. A mishap diagram is essential for an investigation team because it assists in determining solving the cause of a mishap after the wreckage has been removed.

1. Define The Goal

The goal of the example application is to instruct United States naval officers on the process of constructing and evaluating aircraft mishap diagrams. The application will include a presentation on how to construct a wreckage diagram and then provide a user with an opportunity to construct a wreckage diagram based on a video of an aircraft impacting the ground and photographic representation of a mishap site.

2. Identify The End Users

The end users for the example application are United States naval aviators. A profile of a typical end user is:

- Bachelors degree.
- Highly motivated.
- Has been through rigorous flight training.
- Has an interest in mishap investigation. Normally at some point in their careers they will have involved either directly or indirectly with an aircraft mishap.
- Varying levels of computer experience.

3. Define Detailed Learning Objectives

The learning objectives for the example application are:

- Construct and analyze an aircraft mishap wreckage diagram in accordance with naval aviation mishap publications.
- Determine the proper type of wreckage diagram to use based on the mishap site.

Using the learning objectives, the ways of presenting the information are based on the CDT theory. The two types of presentation methods are task performance and tutorial. The task performance presentation will be based on the first learning objective and tutorial will used for the second learning objective.

4. Define Application Type

The application type should be both passive and active. The user should be presented with the proper procedures for constructing a wreckage diagram and then be required to construct one given a photographic representation of a mishap site.

5. Develop Metaphor

The metaphor used in this example is role playing. A user will put in the role of a mishap investigator attempting to determine the cause of an aircraft mishap. A user will be presented with information that requires building a mishap wreckage diagram from two pieces of evidence: a video segment of an aircraft hitting the ground and a photograph of the a mishap site. If a user needs assistance with this task they may go to a tutorial that shows how to create three different type of mishap wreckage diagrams.

6. Information Search

The information resources search included

- Interviews with experts in field of mishap investigation from the Naval Aviation Safety School.
- Various publications in mishap investigation provided by the Naval Aviation Safety School.
- The developer's personal experience as a naval officer and an aviator.

7. Resource Quality

The example application was constructed by one developer and required 12 hours to prototype using a high end multimedia authoring tool.

8. Media Collection and Storage

The media used in the example application was derived from aircraft investigation manuals acquired from the Naval Aviation Safety school located at the Naval Postgraduate School. The wreckage diagrams were derived from the NAVAIR

00-80T-116-1 manual and put in digitized format. In addition to the wreckage diagram, a video showing an aircraft mishap site has also been provided.

The Microsoft Windows® File Manager provided the necessary access and organization for the media used in the application.. For a more complex application a multimedia database would be essential for documenting media. Copyright infringement was not an issue in the application because all material is in the public domain..

9. Media Editing

Media were edited with IconAuthor®. The tools available with IconAuthor® were sufficient for this application, however, for a more involved application, a more feature rich tool would be required. Instead of a simple bitmap editor an image editor would be essential.

E. DESIGN PHASE

1. Divide Application Into Manageable Pieces

The application is broken down into three modules:

- Introduction.
- Tutorial.
- Task performance.

The introduction displays the learning objectives of the lesson and also provides a path to the two other modules shown in Figure 3-2 and Figure 3-3. The modules in Figure 3-2 and Figure 3-3 would be considered children of the screen shown in Figure 3-1 in the Amsterdam Hypermedia model example.

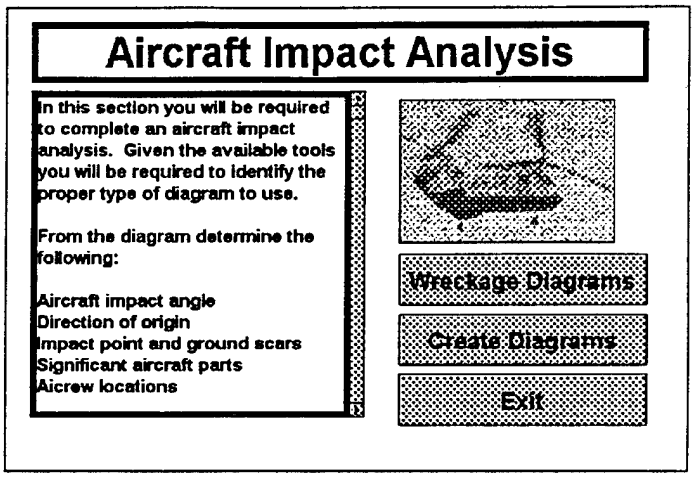

Figure 3-1

Figure 3-1 is a brief introduction to aircraft impact analysis. It provides the opening screen to the rest of the modules. The learning objectives for the lesson are summarized in the text box in Figure 3-1.

The wreckage diagram types are displayed in Figure 3-2. These screens make up the tutorial portion of the lesson. There are three mishap diagram types used in aircraft mishap investigation: polar, grid, and tear drop. Each screen provides an example and a description of each diagram type.

The wreckage diagram creation module shown in Figure 3-3 is provided to give a student the opportunity to create a mishap diagram. Based on a video or animation of an aircraft hitting the ground and a photograph of a mishap site, a student using an electronic drawing program, prepares a mishap diagram using one of the three diagram types. The media used to show the aircraft impact would be of three different impact scenarios, each requiring a different wreckage diagram type.

2. Design Storyboards

The storyboards were first designed using pencil and paper. The paper diagrams were converted to digital representations using IconAuthor's® Smart Object editor. The Smart Object Editor provided a set of interface creation tools simplified the storyboarding

process simple. Using some general concepts of interface design, storyboards were prototyped in one day.

An attempt was made to ensure that consistency, continuity and information balance were held during storyboard creation. The consistency is apparent in that all of the storyboard looking similar with title boxes and navigation controls in the same place (Hodges and Sasnett, 1993).

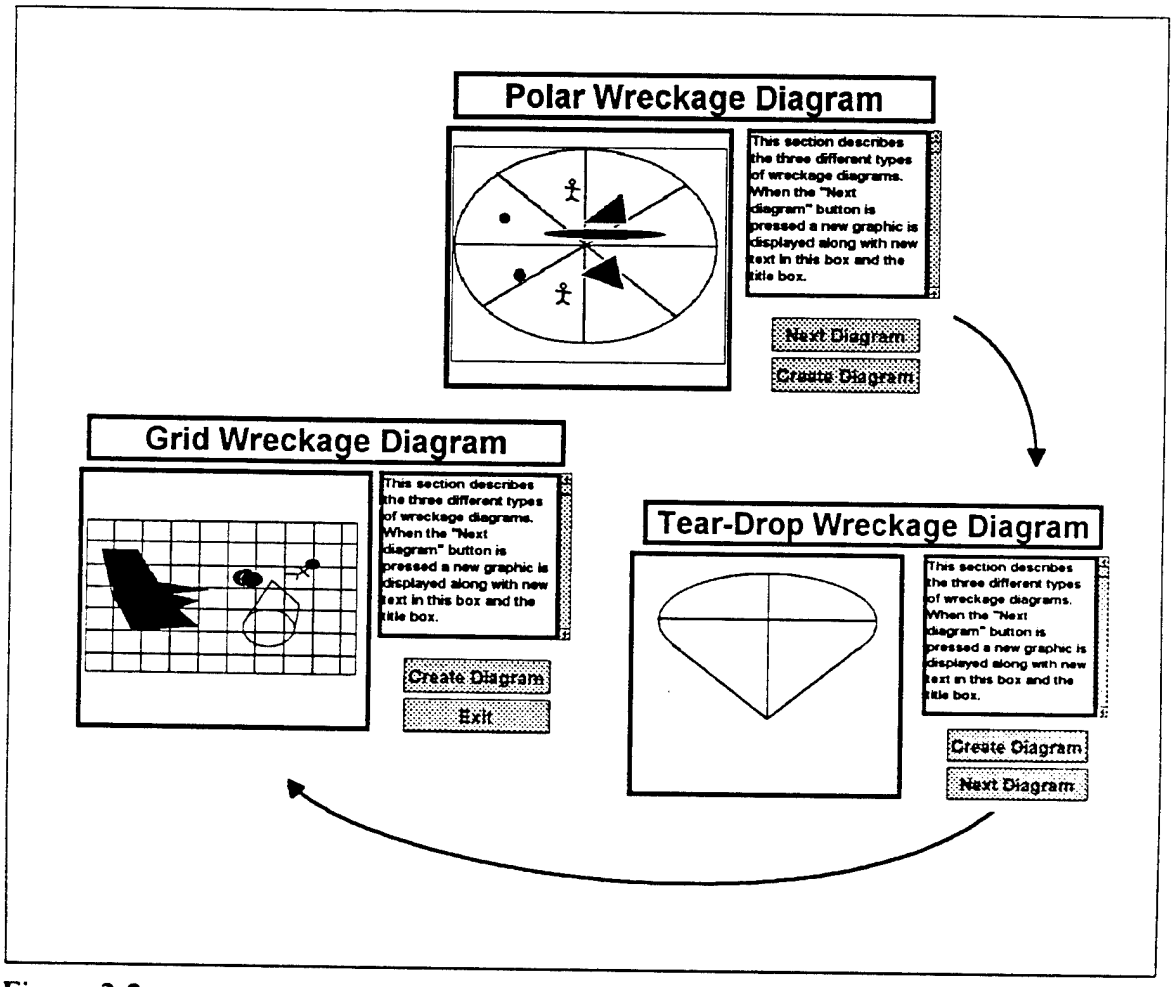

Figure 3-2

3. Define Media Components

The media components used in this application were various and included: text, graphics, sound, video, animation, and an Object Linking and Embedding (OLE) object

used for drawing. The primary text components were the title boxes and the information boxes shown in each. The graphic components were the opening screen helicopter graphic, the mishap diagram graphics, and the mishap site graphic images. The video and animation are used in the wreckage diagram creation module to show an aircraft impact. In this case an animation sequence would be preferred. The video and animation for this project are still in work.

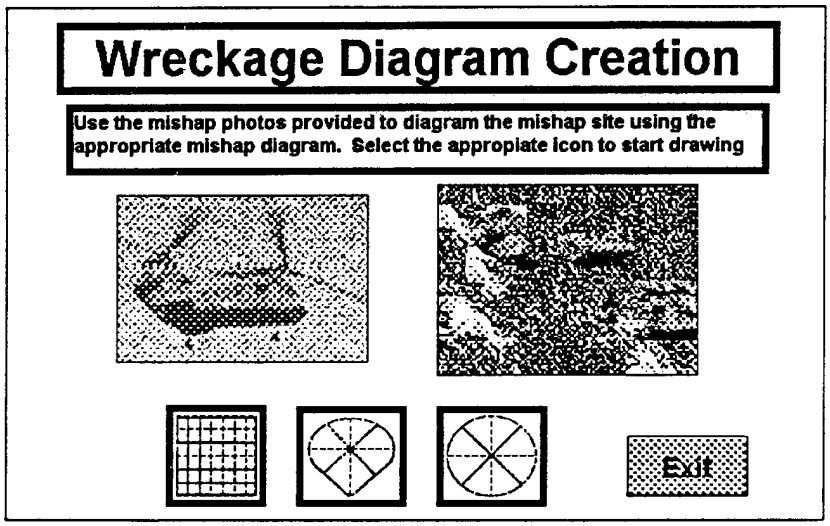

Figure 3-3

Microsoft Paintbrush® was used as the embedded drawing tool. Paintbrush was available within Microsoft Window and served the purpose of making sketches of mishap sites based on the media presented.

4. Define Navigation Components

The navigation components for this lesson are the buttons found on each screen and the three icon displaying the embedded drawing program in Figure 3-3. An example of the links and anchors that make up a navigation component are shown in Figure 3-2. The buttons displaying "Next Diagram" are anchors on one end of the link while the entire screen is the target anchor at the other end of the link.

The entire screen can be considered an anchor because every screen has the attributes of a composite components. The buttons showing "Create Diagram" in Figure

3-2 are links to the screen shown in Figure 3-3. The button labeled "Exit" in Figure 3-3 will exit the drawing screen and is linked to the screen shown in Figure 3-1.

5. Define Channels

There are a several channels defined in the application. The title text box displayed at the top of each screen is an example of a channel. In Figure 3-1, the contents of the text box is aircraft impact analysis. The channel has a default text box frame size, font, font size and color but the content is different. In addition, in Figure 3-2, the three storyboards all display the same presentation but each storyboard contains different content.

IV. CONCLUSIONS

A. CONCLUSIONS

The framework developed in this thesis is only part of the whole development process. The analysis and design phases are the parts of the development process presented. The framework is successful because it allows the development process to implementation independent. The framework can be used as template for starting a application development effort and may be modified to suit an individual's needs. The outputs of the framework, such as storyboards and media components give a developer a specification from which he or she can work independent of the software used form implementation.

Instructional development merged nicely with multimedia development. A systematic design process was used to develop lessons and then migrate the lessons to a multimedia presentation. The most difficult part of creating presentation was trying to determine how to present material and in which format: tutorial, drill and practice or simulation. An additional difficulty was in selecting the proper media to present learning objectives

Traditional methods of software specification and design are were not suitable for multimedia applications. Data flow diagrams and structure charts did not provide the right tool for assisting in multimedia development. The framework provided tools that are work well suited to creating multimedia applications.

Additional research that would augment this framework are:

- expand the framework to make it more comprehensive
- implement a storyboard creation tool that would also create specifications similar to those in the Amsterdam Hypermedia model.
- create a methodology for applying the most suitable media based on the information to be relayed to the student.

Applying multimedia to education is a valuable tool that will be used more in the future. Developing ways to improve educational multimedia need to be expanded and explored.

B. DOD RELEVANCE

Education and training is required for maintaining readiness in the Department of Defense. The DoD spends millions of dollars annually for education and training. During this period of "right sizing" in the DoD computer based education and training can assist in decreasing expenditures on education and training (Miller, 1991). The framework presented in this thesis will assist DoD in designing and specifying educational multimedia applications.

C. PRIMARY RESEARCH QUESTIONS

1. Can An Effective Framework Be Developed To Guide Educational Multimedia Development?

Yes, an effective framework can be developed to guide educational multimedia development. The framework presented here provides an easy to use, implementation independent guide to developing educational multimedia applications.

Using the framework in conjunction with a screen creation tool such as IconAuthor® or Authorware®, an application prototype can be created in a short period of time. The prototype provides a structure to continue development. The prototype gives an end user an idea of what the application will look before it is constructed. In addition, the framework gives guidance for application specification that is essential to continued application development and maintenance. The sample application developed for this framework was constructed in one day.

No frameworks for educational multimedia development could be found in the academic or practitioner literature. The only material resembling a framework was Mallon's (1994) World Wide Web home page. While the page provided some answers, it was not complete and did not address the educational issues needed by this framework.

The Amsterdam Hypermedia Model provided tools for creating a specification for a multimedia application. In addition, it provided a structure for presenting media and navigating through it.

D. SECONDARY RESEARCH QUESTIONS

1. Can Systems Analysis And Design Be Integrated Into Such A Framework?

Systems analysis and design provided a guide to putting this framework together. A systematic approach to problem solving and systems development is an excellent methodology on which to build a more specialized framework. System analysis and design was successfully integrated into the framework. This integration is validated by the systematic approach this framework takes in developing educational multimedia.

2. Can Object-Oriented Analysis And Design Be Integrated Such A The Framework?

The only aspect of object-oriented design used was putting multimedia information into components or composite components. The media objects or components are intended to have their functionality encapsulated within their respective specifications. For example a graphic will display itself. A functional description could be written display (window size, location)

3. How Can Structured Systems Design Be Integrated Into Such A Framework?

Structure systems design was not integrated into the framework. Structured design did not seem to fit well into the problem.

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